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FIELD TESTING OF AUTOMOTIVE ENGINES

Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland

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13. ABSTRACT

Provides guidance for development testing of field performance of automotive engines installed in wheeled and tracked vehicles. Describes preliminary activities and requirements for initial inspection, servicing, and safety evaluation. Lists supporting tests including those applicable to engine performance under severe operating conditions. Provides supplementary instructions covering basic vehicle subtests and endurance, durability, and reliability. Designed primarily for reciprocating internal combustion engines but applicable to other types.

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AMSTE-RP-702-101

Test Operations Procedure 2-2-721

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FIELD TESTING OF AUTOMOTIVE ENGINES

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SECTION I
GENERAL

1. Purpose and Scope. This TOP provides guidance for planning field performance tests of automotive engines to assure their conformance with Required Operational Capabilities (ROC's), Development Plans (DP's) and other guidance documents. Subtests suitable for meeting the requirements of development tests I, II, or III or other customer sponsored tests can be selected from those listed in section II. This TOP is primarily applicable to reciprocating internal combustion engines, both spark-ignition and compression-ignition (i.e., diesel), but may be used for tests of other types such as rotary engines. Tests conducted are limited to those which can be accomplished with the engine mounted in the vehicle. When engine removal is required, the provisions of TOP/MTP 2-2-700 (laboratory tests) will apply.

2. Background.

a. Automotive engines developed to power U. S. Army vehicles must be tested to assure suitability for their intended purposes, with acceptable endurance and maintainability. In most cases, the test of the engine is part of the overall test of a vehicle, and its performance

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is generally measured by such subtests as fuel consumption, cold starting, drawbar pull, endurance, and obstacles. In other cases, samples of the same vehicle may have two different types of engines which must be compared. In a third case, a vehicle that may be already fully tested may be retrofitted with a new or modified engine to improve performance or reduce costs. Though procedures described herein are applicable in all three cases, they are directed mostly to fulfill the third case.

b. Before an engine is submitted to TECOM for testing, usually it will have as a minimum been tested for performance in a laboratory by the commodity command (such as TACOM), and, if appropriate, it will have been certified regarding pollution potential by the U. S. Environmental Protection Agency.

3. Equipment and Facilities. Equipment and facilities are covered in the references of Section II.

SECTION II TEST PROCEDURES

4. Preliminary Activities.

a. Review of Test Guidance.

(1) For vehicles being subjected to development tests (DT) I, II, or III, the subtests that are selected by the test agency are governed by requirements in the ROC's and DP's. For retrofitted engines or comparison tests of engines, test guidance is provided by test directives from supervising agencies. The levels of acceptable performance are usually stipulated. If adequate test guidance does not exist, the test plan writer will make appropriate inquiries to the responsible directorate at TECOM.

(2) Certain important characteristics, especially those involving advanced engineering technology, may not be specifically covered by the requirements document but should nevertheless be included in the test plan and evaluated as a part of the DT I, II, or III, per AR 1000-1. These may include such features as noise measurements, transient voltages, and electromagnetic interference and emissions.

(3) All technical and instructional material issued with the test item by the manufacturer, contractor, or Government as well as reports of tests conducted on similar engines should be reviewed.

(4) A safety statement that includes information pertaining to operational limitations and specific hazards peculiar to the test item should be on hand from Hq, TECOM. As appropriate, a certificate of approval may be available from the U. S. Environmental Protection Agency.

b. Use of Referee Grade Fuels.

(1) In addition to standard grade fuels, referee grades equivalent to fuels available in times of national emergency may be required by higher command in some of the field testing of automotive engines. The fuel should be of minimum quality not only from the standpoint of octane or cetane values but also with respect to volatility, additives, and contamination that could affect an engine's endurance characteristics. Such grades are covered by references 5 and 6 (appendix). Since engine performance in many respects is affected by the oil used, consideration should be given to the use of compatible referee-grade engine oils.

(2) The purpose of establishing and using referee grade fuels is that these items are specially prepared to represent the worst case of standard items; that is, they represent the absolute minimum quality permitted under existing specifications. During normal times fuel is produced at a quality above minimum requirements, but in a national emergency the quality of fuels will probably be lowered. If engines will operate on referee grades, they will likely operate on the reduced quality fuels and lubricants expected to be available during periods of emergency. Tests of fuels and lubricants are covered in TOP 2-2-701.

c. Selection and Sequencing of Subtests.

(1) Automotive engines must be tested in accordance with the service requirements of the vehicle(s) that they are intended to power. Because of the variety of military vehicles and service requirements, vehicles are grouped by mission for test design purposes. TOP/MTP 2-2-506 describes wheeled vehicle groups and provides test course schedules (mileage, type of course, cycles per course) for each group. TOP/MTP 2-2-507 provides similar schedules for tracked vehicle groups. Unless special requirements for engine performance are indicated in the ROC, DP, or other governing document, extended operations are conducted under the procedures prescribed in these TOP's for the purpose of obtaining data on endurance, maintainability, reliability, human factors, and fuel and lubricant consumption. Other specialized tests are also conducted to evaluate certain performance characteristics and the ability of the engine to perform under taxing conditions.

(2) Supporting tests (in the order of decreasing risk) to be considered in formulating a test plan, together with appropriate common TOP/MTP and other references, are as follows:

<u>TITLE</u>	<u>PUBLICATION NO.</u>
(a) Initial Inspection (refer to para 5)	2-2-502
(b) Break-In Operations	2-2-505

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<u>TITLE</u>	<u>PUBLICATION NO.</u>
(c) Safety Evaluation (refer to para 6)	2-2-508
(d) Electrical System	2-2-601
(e) Fuels and Lubricants	2-2-701
(f) Acceleration - Maximum and Minimum Speeds	2-2-602
(g) Fuel Consumption	2-2-603
(h) High Altitude Effects	2-2-702
(i) Drawbar Pull	2-2-604
(j) Engine Cooling	2-2-607
(k) Gradeability and Side Slopes	2-2-610
(l) Field Shock and Vibration	2-2-808
(m) Standard Obstacles	2-2-611
(n) Fording	2-2-612
(o) Radio Interference Suppression	2-2-613
(p) Toxic Fumes	2-2-614
(q) Security from Detection	2-2-615
(r) Cold Starting and Warmup	2-2-650
(s) Human Factors Evaluation	2-2-803
(t) Noise	3-2-811
(u) Reliability and Endurance (refer to para 8)	2-2-506, 2-2-507
(v) Maintenance Evaluation	1-2-501, TECR 750-15

d. Personnel Orientation. All test personnel should be familiar with safety precautions, technical and operational characteristics, and the scope of tests applicable to the engine being tested.

e. Preventive Maintenance and Inspections. A schedule of preventive maintenance services and inspections should be prepared in accordance with the applicable maintenance manual.

5. Initial Inspection and Servicing.

a. An initial inspection is conducted to assure that the test item is in good condition and that pertinent pretest data are compiled prior to initiation of the test program. Included are:

(1) Serial numbers and other identification of engines and major accessories.

(2) Major physical dimensions and tabulation of important features.

(3) Characteristics photograph.

(4) Results of examination of maintenance test package for completeness.

(5) Electrical system output (per TOP/MTP 2-2-601).

(6) Odometer mileage and engine-hour readings.

b. The engine and its accessories are completely serviced to include draining of fluids and refilling with standard fuel, lubricants, and other fluids. The identification and quantity of all fluids used are recorded, and attention is called to unusual quantities. If drain or fill times are unreasonably long, these should be noted together with information on influencing factors such as size of drain plugs.

6. Safety Evaluation. An interim safety release should be generated within 60 days of test initiation. The interim safety release recommendation is given based on subtests performed early in the test. The subtests include, but are not limited to, preliminary operation, gradeability, side slopes, toxic hazards, speed, and obstacles. The safety evaluation does not end with the issuance of the safety release: it is considered to be a continuing subtest throughout the test program.

SECTION III
SUPPLEMENTARY INSTRUCTIONS

7. Vehicle Subtests. The basic subtests to use in conducting engine tests are listed in paragraph 4c(2). Consideration should also be given to the subtests and guidance provided in the TOP related to the specific vehicle under test. Vehicle TOP's are:

2-2-014 Carriers, Full-Tracked
2-2-040 Missile Support Vehicles

2-2-070	Main Battle Tanks
2-2-100	Trucks and Tractors
2-2-101	Fire Trucks
2-2-131	Recovery Vehicles
9-2-064	Crane Shovel, Tracked and Wheeled
9-2-082	Earthmoving Equipment

8. Endurance, Durability, and Reliability.

a. Endurance is a general term that is concerned with the ability of a vehicle and engine to perform satisfactorily under typical field conditions for long periods of time. As indicated in paragraph 4c(1), the vehicle endurance test schedules of TOP's 2-2-506 and 2-2-507 apply to the endurance testing of engines unless otherwise prescribed by the directive or guidance document.

b. Durability is a precise term that relates to the mathematical probability that an engine will be able to operate under typical field conditions for a specified number of miles before requiring major overhaul. Since durability tests require many samples and considerable funding, they are seldom conducted; the endurance test, which is much more limited, is usually conducted instead. TOP 1-2-502 describes a durability test and provides guidance for selecting sample sizes and distances. Current doctrine, AR 702-3, indicates that success of a durability test will be based upon a point estimate. For example, a .9 probability will require that 9 of 10, or 10 of 10, vehicles must successfully complete the prescribed mileage without a durability failure.

c. Reliability is defined as the probability that an item will perform its intended function for a specified time under specified conditions (i.e., the probability of successfully completing a mission without incurring a mission-aborting failure). The reliability requirement is usually expressed as a probability of success for one or more specified operational and environmental cycles or functional sequences (mission). This requirement may be expressed in several ways; e.g., as an acceptable mean-time-between-failure (MTBF). In the MTBF context "T" may be expressed as hours, cycles, rounds, miles, etc. Most of the data for the reliability determination are obtained from the endurance test, which simultaneously provides data for the maintenance evaluation.

d. Endurance, durability, and reliability are being more fully covered in TOP/MTP 2-1-001.

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APPENDIX
REFERENCES

1. AR 702-3, "Army Materiel Reliability, Availability, and Maintainability (RAM)."
2. AR 1000-1, "Basic Policies for Systems Acquisition by the Department of the Army."
3. TECR 385-6, "Verification of Safety of Materiel During Testing."
4. TECR 750-15, "Maintenance Evaluation During Testing."
5. MIL-G-46015 (MR), "Gasoline, Automotive, Combat; Referee Grade," 8 September 1967.
6. MIL-F-46162 (MR), "Fuel, Diesel, Referee Grade," 27 June 1973.